

# Neutrino electromagnetic properties and magnetic moment induced transition of neutrino between different mass states

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**Keywords:** neutrino, magnetic moment

Neutrino electromagnetic properties reveal an essential area for search for new physics beyond the Standard Model (refer to [1] for the recent review). The number of experiments makes it rather natural that neutrino possesses nonzero mass as well as magnetic and, probably, electric moments. With these fundamental characteristics of neutrino here come to light the possibility of multiple applications of them, particularly in astrophysics and cosmology.

Due to nonzero diagonal and transition magnetic moments neutrino is able to interact with photons. Considering neutrino propagation in matter (for example, in a neutron star), a new mechanism of electromagnetic radiation by neutrino has been proposed [2] and it is called the Spin Light of neutrino (SL $\nu$ ). The quantum theory of the process has been developed in [3], based on the method of exact solutions [4] of the modified Dirac equation. Neutrino interaction with matter averages in energy difference between initial and final neutrino states providing an opportunity to emit light. Note that the effect critically depends on the neutrino helicity.

Here we consider the transition of neutrino between two different mass states as a development of the theory of SL $\nu$ . Though the process of the neutrino decay in vacuum and in matter has been studied before (for example, in [5]), in our analysis we use neutrino

wave functions, exactly accounting for the presence of medium, while the previous investigations have accounted for matter only in the vertex function.

Below there are the process rates for the most interesting ranges of parameters: ultra-high, high density and quasi-vacuum cases correspondingly

$$\Gamma = 4\mu^2 \tilde{n}^3 \left(1 + \frac{3}{2} \frac{m_1^2 - m_2^2}{\tilde{n} p_1} + \frac{p_1}{\tilde{n}}\right), 1 \ll \frac{p_1}{m_1} \ll \frac{\tilde{n}}{p_1}; \Gamma = 4\mu^2 \tilde{n}^2 p_1 \left(1 + \frac{\tilde{n}}{p_1} + \frac{m_1^2 - m_2^2}{\tilde{n} p_1} + \frac{3}{2} \frac{m_1^2 - m_2^2}{p_1^2}\right), \frac{m_1^2}{p_1^2} \ll \frac{\tilde{n}}{p_1} \ll 1;$$

$\Gamma \approx \mu^2 \frac{m_1^6}{p_1^3}, \frac{\tilde{n}}{p_1} \ll \frac{m_1}{p_1} \ll 1, m_1 \gg m_2$ . For slow and heavy initial neutrino in vacuum we obtain the rate  $\Gamma \approx \frac{7}{24} \mu^2 m_1^3 \sim m_1^5$ , which is in agreement with neutrino radiative decay rate [5]. Here  $\mu$  is neutrino transition magnetic moment,  $\tilde{n}$  is matter density parameter,  $m, p$  are mass and momentum of the initial(1) and final(2) neutrinos. For further details see [6].

**Acknowledgements.** One of the authors (A.S.) is thankful to Professor George Tzanakos for the invitation to attend this great neutrino meeting.

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